members of the senior staff who may be concerned with the problems presented by individual patients. The various aspects of the cases are then discussed at the daily visits when all the members of the medical department join the house staff in the wards. In addition to these exercises, of a strictly clinical nature, other opportunities are provided to enable the men to keep in touch with the work which is being done by their colleagues in Peking and elsewhere in the medical world. On Saturday mornings the whole staff meets for an hour in the laboratories while one of the members talks to them about his researches, or about some of the broader fields with which he is in close touch; once a fortnight the Medical Society meets for the more formal presentation of papers; and at a similar interval the "Review Club" discusses special topics from the medical literature. The fact that the faculty of the medical school is so large (about forty members, besides assistants in clinics and laboratories), that so much progressive scientific work is being carried on in all departments, and the relations between the departments are so intimate and harmonious, makes it almost impossible for one to be a member of the staff and fall by the professional wayside. To many people in America, China may seem to be remote and Peking an outpost of western civilization, but to those who know the situation the Peking Union Medical College is progressing hand in hand with the foremost medical schools of the world on the frontier of scientific medicine.

FRANCIS W. PEABODY
BOSTON CITY HOSPITAL

## A FIRST COURSE IN GENERAL CHEMISTRY[1]

THE opportunity to take part in a discussion on the above topic is highly appreciated, particularly because during the past twenty years I have had an exceptional opportunity to try out certain ideas relating to the teaching of general chemistry to first year students at the Phillips Exeter Academy. Since Dr. Gordon stated that I could confine the discussion either to content or method or both I shall probably avail myself to the limit of this proviso.

Since my main criticism of the majority of papers thus presented has been that the statements have been too general, and that there has been too little of what was definite and capable of being carried away by the listener and put into immediate practice, perhaps I may be allowed to speak rather personally in parts, and to mention existing texts by name.

There stand before me on the desk fourteen of the more modern texts from which the secondary school teacher must usually choose the one to use with his classes. From these, three must reluctantly be dropped out of our consideration. The excellent "Text-book of Chemistry," by W. A. Noyes, is designed for use with college students, although it is so written as to be suitable for college students who have had no chemistry. As I interpret the subject before us to refer to the first year student in chemistry during his period of *preparation for* college, we must consider the large difference in the mental attitude of the student towards his subject manifested in the last years of secondary school and in the early years of college. Vivian's "Every-day Chemistry" and "Chemistry and Its Relation to Daily Life," by Kahlenberg and Hart, must be laid aside because, although they are designed for use in secondary schools, they are adapted particularly to students of agriculture and home economics. Students, should, however, have access to these two texts which show successfully how live and every-day a subject chemistry is.

In this connection it may be interesting to note that at a recent meeting of the New England Association of Chemistry Teachers a textbook survey was made. Of those present about one third used McPherson and Henderson's "Elementary Study of Chemistry," about one third used "Elementary Principles of Chemistry," by Brownlee and Others, while the remaining one third were divided among McFarland's "Practical Elementary Chemistry," Black and Conant's "Practical Chemistry" and Newell's "Chemistry" in about the ratio of 2 : 2 : 1, respectively. I shall have occasion to refer again to these five books, as well as incidentally to the other six before me.

I have never been able to understand why

[1] Paper read before the American Chemical Society at its meeting in April.

practically all texts written for the beginner in chemistry start in with oxygen, hydrogen, the gas laws, and water, to be followed soon with atoms, molecules, symbols, formulas and equation writing. It has always seemed to me more logical to start, not with gases, but with some solids, such as metals, with which the student may have had some slight acquaintance before entering the class. It is my belief that the ordinary student can at first get more tangible results from the more tangible substances, and that introducing him from the start to gases which he can hardly see, smell, taste, or handle is likely to discourage him from the start, particularly if these introductory substances are tangled up with that bugbear to so many students—the gas laws. A splendid opportunity is lost to tie the subject from the beginning in the student's mind to things that he has handled, or can handle, easily in every-day life.

My convictions were so strong that some years ago I worked out a scheme of experimentation in which the student started with such common metals as copper, zinc and iron, and followed these with magnesium, phosphorus and mercury. After a rather full study of the properties of the elements themselves, heating them in air introduced him to the subjects of oxidation and combustion. Without going into details, I might say that the first ninety experiments led him through sulfur, carbon and chlorine and the acids formed from these, the analysis and synthesis of water, and then sodium, potassium and calcium and their common compounds in such a way that each experiment grew naturally out of those preceding it and led up to an investigation of a (to him) unknown substance, namely, saltpeter, which he investigated by means of sulfuric acid and by appropriate experiments on the distillate, with the result that by this procedure he determined for himself the composition of both saltpeter and nitric acid. All of this work was completed without the mention of atom or molecule and without a symbol or a formula. It is my belief that the performing of these ninety experiments revealed to the student the methods of thought used by the chemical investigator in attacking his problem—the same method that he (the student) should use on a small scale in solving his own difficulties. I tried in this way to teach the student how to *think* his own way out of his difficulties.

You will probably be asking if no equations were used in these experiments. Yes, there were—the kind of equation that McPherson and Henderson hint at in their chapters on oxygen and hydrogen in both of their texts. Newell, Brownlee, Black and Conant and some others use the same device to a limited extent, but I developed that form of equation writing so that instead of using the names of the compounds with pluses and arrows, the student early got into the habit of representing each chemical reaction by an equation in which each compound was represented by the names of the elements which they had discovered that compound to contain, each compound being enclosed in a set of brackets. By this method the students acquired a very personal and first-hand acquaintance with the behavior of many chemicals with each other, and they got a very good conception, based upon actual laboratory work, that certain compounds contained such and such things, not because the formula was, for instance, $Na_2SO_4$, not because the book said so, but because they had proved it themselves. It must be admitted that such an attitude in the student's mind is not to be scoffed at. The main question that arises is: "Have we time nowadays for such a method, or is the subject so big that we must present the material in a pretabulated and almost in a predigested form?"

Of course this set of ninety experiments was simply introductory to text matter on the theory in chemistry with experiments to illustrate the laws and principles. Then came symbols and formulas and their use in equation writing, and finally considerable descriptive chemistry studied in the light of present theoretical conceptions, but with the spirit of the inductive method still an unconscious guide.

It is only fair to say that in those years each student performed probably 150 or more experiments, and that although it was my opinion that he was being taught *chemistry* rather than a *text-book,* the school year was not long

enough in which to prepare him by this method for the examination set by the college entrance examination board, although these same students had little or no trouble in passing the Harvard chemistry paper as set at that time. As the business of our school is to fit students for the college examinations it will be evident that by working out this little piece of educational research I was sacrificing much and I reluctantly had to decide to replace my own text with one of the other texts already mentioned. But I satisfied myself that the chemical instruction as ordinarily practiced was susceptible of considerable improvement and that in my own mind I was on the right track.

As I look back at the experience now I suspect I overdid the laboratory side of the scheme, and it seems plausible that an abbreviated and modified presentation following my general outline might perhaps lead to a more generally accepted method of presenting our subject. I have gone into some detail on this method, not because I think it might offer the eventual solution, but incidentally to show what has been done and primarily as a protest against the stereotyped method of plunging the beginner into the intangibility of gases.

Bradbury's "Inductive Chemistry" is the only text I have seen that approximates the method I have outlined. This book starts the student on sulfur, leads on through compounds of sulfur with some familiar metals to some metals themselves, and then takes up carbon as an example of a non-metallic solid; he loses out, however, by making all this textual instead of the basis for laboratory work. Lest I give a wrong impression of this book let me add that succeeding pages deal with oxides, atomic theory, hydrogen compounds, the sodium group, the chlorine group, and oxy-acids and their salts.

The student should certainly have a clear conception of the terms and phrases he uses in talking about chemistry, but I doubt very much if the extreme niceties of definition and fine drawings of line that characterize Alexander Smith's books are likely to appeal to the beginner, however much the teacher may admire these qualities.

Blanchard and Wade's "Foundations of Chemistry" is a valuable addition to elementary chemistry literature, and agreeably attractive, too, but I always lay it down feeling sorry that so many things are not there. I have never been able to get really enthusiastic over Hessler and Smith's "Essentials of Chemistry"; the directions for the laboratory work look more satisfactory than the text itself. Perhaps the too frequent use of fine print leaves the impression that much of the material presented is not of prime importance. Dull's "Essentials of Modern Chemistry" strikes closer home. It makes me wish I were a student again and just beginning chemistry, although he too starts in with oxygen, hydrogen and water, and that conflicts with my pedagogical ideas.

For several years now we have been using at Exeter Brownlee's text, but we tie up with it McPherson and Henderson's "Laboratory Manual," as we consider this manual better worded for and better suited to the elementary student.

The chemistry syllabus of the college entrance examination board has been a valuable aid in indicating to secondary school teachers what topics should be covered in the first year's course. It has been noted by some teachers, however, that those who set the paper sometimes seem to feel that the paper they set should touch in some way on almost every topic in the syllabus. This fact, together with the large number of topics in the syllabus, make it necessary for the teachers to spend the whole year covering the topics in the syllabus. If a majority of the colleges could agree to be satisfied with a smaller number of topics but have these covered more thoroughly, perhaps the board would revise the chemistry syllabus accordingly. This would be a boon to many teachers in that they would have time to cover the essential parts more thoroughly and would have a little time left to dwell upon such special topics as they find appealing to their classes or appropriate to the localities where they teach. I feel sure that secondary teachers may be depended upon not to take advantage of such diminution in requirements. Those who might be thus guilty could with advantage to the profession be eliminated.

Elementary chemistry teachers are much indebted to the college men who have written

chemistry texts for them and for the vast amount of time and thought they have spent in the preparation thereof. I often wonder, however, if the college teacher who lives and works among college students and does some research on the side can be expected to guage the needs of the secondary student and to put himself in the place of the secondary school teacher. If such a college man could have an opportunity to fill the position of a secondary school teacher of chemistry for a period of say five years, and have to make his living thereby, I'd welcome a text he might produce. Or must we wait till the profession of chemistry teaching in secondary schools has become sufficiently established to attract men of the requisite scholarship, knowledge of chemistry, acquaintance with what the colleges should require for entrance, and above all a close knowledge of the mental equipment of students of secondary school age before we can expect a solution of the problem: "What should be taught in first year chemistry and how should it be presented?"

WILHELM SEGERBLOM
PHILLIPS EXETER ACADEMY

## THE PHYSICO-CHEMICAL MECHANISM OF MUTATION AND EVOLUTION

IT is the general rule in biology that descendants resemble parents, and that a parent organism can not pass on to offspring a factor which the parent did not receive from the germ-plasm of its immediate progenitors. Many apparent exceptions to this general rule have been traced to the existence in the parent gametes of recessive factors, which, while suppressed in the parent, may be liberated again in the offspring. Whether we accept the view of Darwin that large differences can represent the summation of small differences, or the more probable view of Bateson and others, that mutation or variation is a definite physiological event, no satisfactory explanation has been given as to the origin or source of these exceptions to the general rule of resemblance, although they constitute the steps by which evolution haltingly proceeds.

The crying need that we must find a chemical, physical or physico-chemical basis for mutation or variation has been voiced by many. Thus in his address before the British Association for the Advancement of Science (Australia, 1914, reprinted in *Smithsonian Report*, 1915, pp. 359-394), Sir William Bateson says: "Every theory of evolution must be such as to accord with the facts of physics and chemistry, a primary necessity to which our predecessors paid small heed. . . . Of the physics and chemistry of life we know next to nothing. Somehow the characters of living things are bound up in properties of colloids, and are largely determined by the chemical powers of enzymes, but the study of these classes of matter has only just begun. Living things are found by simple experiment to have powers undreamt of, and who knows what may be behind?"

Recently R. S. Lillie[1] (SCIENCE, 51, 525, 1920) has stressed the importance of physico-chemical investigation of protoplasm, and Alexander Forbes (SCIENCE, 52, 331, 1920) has called for closer cooperation between physicists and biologists in attacking biological problems.

An attempt will be made here to outline certain basic physico-chemical principles which affect the formation, development, growth and reproduction of living things, and to point out how it is possible for variation in some of the factors therein involved to account for important and transmissible variations or mutations in individual organisms.

At the outset let it be stated that no mysterious or special "vital force" will be evoked, but that the well-known forces that control inanimate matter seem quite sufficient for the purpose.

In nature, both animate and inanimate, the following basic factors tend to produce *symmetrical orientation or aggregation:* (1) Crystallization; (2) Diffusion, as in the formation of Liesegang's rings, agate, etc.; (3) Electric or magnetic fields of force; (4) Harmonious vibration as of air, water, etc. We here disregard mere chance and the conscious arrangement by man.

[1] See also Lillie's interesting papers in *Biological Bulletin*, 1917-1919, and *Scientific Monthly*, February, 1922.